May 7, 1968 M. RYDINGER ET AL 3,382,311

LOW FREQUENCY INDUCTION MELT PLANT

Filed June 7, 1965

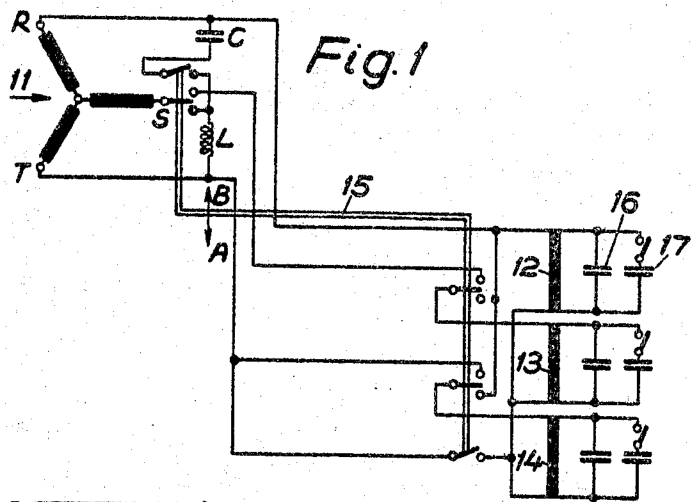


Fig. 1

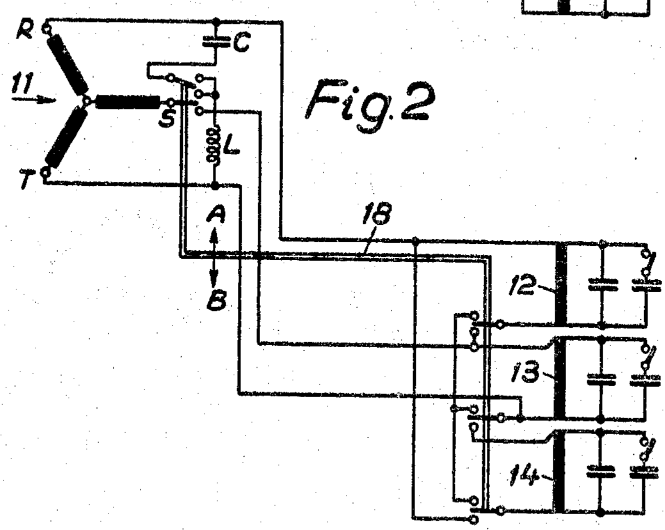
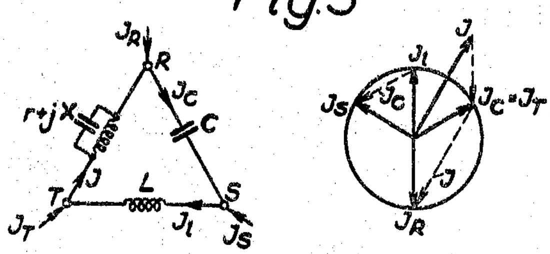


Fig. 2

Fig. 3



INVENTORS

MATS RYDINGER

YNGVE SUNDBERG

BY

Bailey, Stephens & Huettig

ATTORNEYS

United States Patent Office

3,382,311

Patented May 7, 1968

1

3,382,311

LOW FREQUENCY INDUCTION MELT PLANT

Mats Rydinger and Yngve Sundberg, Vasteras, Sweden, assignors to Allmänna Svenska Elektriska Aktiebolaget, Vasteras, Sweden, a corporation of Sweden

Filed June 7, 1965, Ser. No. 462,019
Claims priority, application Sweden, June 18, 1964, 7,495/64
3 Claims. (Cl. 13—26)

ABSTRACT OF THE DISCLOSURE

A low frequency induction furnace has an induction coil formed of three parts with a symmetrizing device and a change-over switch for alternatively connecting the coil over the symmetrizing device to single phase or multiphase to the same multiphase network. The multiphase connection results in motoric stirring.

The present invention relates to a device for network frequency induction melt furnace plants, preferably for those operating under vacuum.

In melting and/or heat retaining of metal melts, such as steel metls, it is usual to connect the furnace coil with single-phase across a symmetrizing device, which in its turn is connected to the secondary windings of a three-phase furnace transformer, suitably provided with tap changers for input regulation. Such a device gives better efficiency than a three-phase connection of the furnace coil (coils).

The single-phase connection of the furnace coil gives a so-called repulsive stirring of the melt. This is mainly symmetrical around the horizontal centre plane of the furnace coil, which means that the melt which is below the centre plane circulates within its part in the same way as the melt above said plane circulates within its part. There is no appreciable exchange of melt between the two halves.

If it is desirable to obtain an improved mixing (homogenizing) of the alloy additives and if it is desirable to expose all parts of the melt to a possible vacuum above the surface of the melt, it is best to effect a motoric stirring. For this purpose a moving field is obtained through the multi-phase connection of the furnace coil, which moves axially and which moves the melt in the same way as the rotating field in the asynchronous motor moves the rotor. Connections for effecting motoric stirring are known.

A certain axial and upwardly directed stirring is thus carried out usually in connection with vacuum on account of upward rising gas bubbles, for example in connection with the formation of CO, which effect is thus limited to the upper part of the melt, while however the bottom of the melt remains uninfluenced. The latter case is particularly common with large furnace where the depth of the melt is relatively great.

The connections for heating in combination which motoric stirring are also known. The stirring is effected then with a separate electrical equipment which has heretofore been constructed for considerably lower frequency than that which is used for heating.

This separate equipment makes the plant considerably more expensive and increases the space requirement.

The present invention effects a simple and space-saving plant, which substantially consists of the components which are used in a conventional network frequency melt furnace plant. The invention is characterised by the furnace being connected alternately single-phase across a symmetrizing device known per se to a multi-phase, preferably three-phase network, or multi-phase/three-

2

phase to the same network. The single-phase connection is used when heating is desired and the three-phase connection for motoric stirring.

It can also be seen that the active heat flow to the melt with the three-phase connection becomes relatively low, so that there is no risk of any undesired overheating, which would be the case with a repulsive stirring in single-phase connection. As sufficient stirring can be obtained within a rather wide range of furnace currents, the current can be chosen within that range in such a way that suitable heat retaining power is obtained.

The invention is exemplified in the accompanying drawings, of which FIG. 1 shows a connection of a low frequency crucible furnace plant with inductive heating with single-phase operation for heating and three-phase operation, Y-connection for stirring. FIG. 2 shows a corresponding plant with three-phase operation, Δ-connection, for stirring. FIG. 3 shows a connection diagram and shows diagrams for a symmetrizing device of known type.

In FIG. 1 at **11** the secondary side of a furnace transformer, Y-connected is shown. The transformer is connected to a three part induction coil **12**, **13**, **14** for an induction furnace or inductive heat retention plant. Parallel with the coils **12–14** are connected one (**16**) or two (**17**) parallel capacitors for phase compensation. Between the transformer and the furnace is arranged a change-over switch **15** for alternate heating-single-phase, and stirring-three-phase. In the case of heating, the change-over switch **15** is placed in the lower position (A). Between phase R and S a capacitor C is connected in this position and between phase S and T a reactance L. The reactance L and the capacitor C are included in the symmetrizing device known per se for single-phase connection of a load to a multi-phase, here three-phase, network and for symmetrical loading of this. Many such symmetry devices are known and this is only one example. Phase R of the transformer is connected to the upper side and phase T to the lower side of the three coils **12–14**.

The symmetry device operates according to FIG. 3. The load (the furnace) $r+jx$ is connected between phase R and T in delta connection. With the letters according to FIG. 3 the following is obtained:

$$I_R = I_C - I$$
$$I_S = I_L - I_C$$
$$I_T = I - I_L$$
$$U_{RS} = IC\frac{1}{jwC}$$
$$U_{ST} = I_L \cdot jwL$$
$$U_{TR} = I(r+jx)$$

If the parallel capacitor (**16**, **17**) for the furnace is chosen so that the reactance $x=0$ at the same time as the reactance L and the capacitance C are tuned to resonance, the following is obtained.

$$wL = \frac{1}{wC} = r \cdot \sqrt{3}$$

and the three currents I_R, I_S and I_T form a symmetrical three-phase system (see vector diagram of FIG. 3).

Complete symmetry can be obtained between the phase currents even with a load which is not purely resistive by not tuning the reactance L and the capacitance C properly, but by giving them values which depend on the resultant impedance and phase angle of the furnace with the furnace capacitor. The power factor of the plant in this case thus becomes lower.

In switching over from heating to stirring, position A–position B for the change-over switch **15** (FIG. 1) the symmetrizing device is disconnected and the coils **12–14** are Y-connected to the transformer **11**. In this position motoric stirring is obtained from the coils **12–14**, fed with network frequency current (50–60 cycles per second).

FIG. 2 shows the same plant as FIG. 1, but with the furnace coils **12–14** connected in Δ-connection. The change-over switch **18** connects in position A the furnace coils **12–14** in single-phase connection across the symmetrizing device L-C and in position B the furnace coils in three-phase connection for motoric stirring of the melt. As seen, the coils are Δ-connected. Tap changing on the transformer is carried out during heating as well as during stirring. The winding connection is not shown. The device according to the invention can be varied in many ways within the scope of the following claims.

We claim:

1. In combination, in a low frequency induction melt furnace, at least one coil, a symmetrizing device, and switch means for alternatively coupling said coil over said symmetrizing device single phase to a multiphase network and multiphase to the same network, in the latter case the melt being motorically stirred in the furnace.

2. In combination, in a low frequency induction melt furnace for vacuum, at least one coil, a symmetrizing device, a three phase transformer having secondary windings, and switch means for alternatively coupling said coil directly and over said symmetrizing device to the secondary windings of said three-phase transformer, in the latter case the melt being motorically stirred in the furnace.

3. In a device as claimed in claim **2**, said symmetrizing device being three-phase coupled to said secondary windings.

References Cited

UNITED STATES PATENTS

1,822,539	9/1931	Northrup	13—26
3,012,083	12/1961	Lundquist	13—26

RICHARD M. WOOD, *Primary Examiner.*

L. H. BENDER, *Assistant Examiner.*